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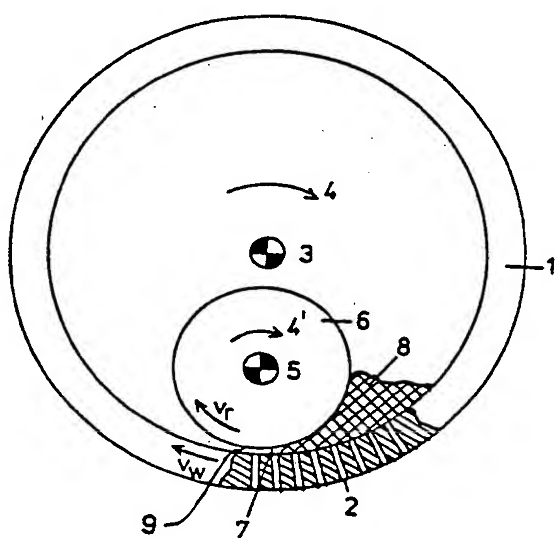

(57) Abstract

A pelleting press for pressing from a powdery, granular and/or pasty material compacted rod-shaped pieces of said material, comprising a die (1) with one or more rotatable rolls (6) co-operating therewith each having an axis (5) supported in such a manner that it is situated in a plane through the axis (3) of the die (1) and a gap (9) is defined between the die (1) and the or each roll (6), further comprising means for supplying the material to be pressed towards the or each gap (9), and driving means for moving the die (1) and the or each roll (6) in respect of the material supplied to the or each gap (9), all this in such a manner that the supplied material when moving in the gap between the die and a roll is compacted and is pressed through the apertures (2), the support of the die and/or the or each roll being so that the gap height is adjustable, the driving means being adapted for driving the die as well as the or each roll, and the velocity of at least the die or the each roll being independently variable.

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Pelleting press.

The invention relates to a pelleting press of the kind mentioned in the preamble of claim 1.

Such pelleting presses are known in several forms, having either a disc-shaped and substantially flat die with a generally vertical axis, rolls having generally a horizontal axis co-operating therewith, or having a cylindrical die with an axis which is substantially parallel to the axis of the roll co-operating with said die. In some presses the axes of the roll and the die are not mutually perpendicular or parallel, but include an angle. The axis of the roll is, then, generally situated in a plane through the axis of the die. Sometimes the rolls are supported in a fixed yoke. As to the drive of such presses, there are presses having a driven die, and presses having a driven roll. With all these drive types, the material to be pressed is entrained by the driven element. The not-driven element moves along with the movement of the material. In some presses, however, the rolls are not supported in a fixed yoke but in a rotatable yoke. The drive will, then, take place by means of the yoke, and the die will generally not rotate. In the known devices, the gap height and the drive velocity will be chosen so that the material to be processed will be pressed as well as possible in respect of the quality of the pressed material pieces (generally called pellets), the production capacity and the energy consumption of the press, but this is done purely experimentally and only as far as allowed by the restricted control possibilities. It has appeared then to be impossible to obtain always an optimal adaptation to fluctuations in the quality, in particular the composition, the internal friction, humidity content and the like, of the material to be processed. In the case of large deviations, for instance so much slip between the material and the die or roll can occur that the pressure in the gap will strongly decrease, and the material will no longer be pressed through the die apertures. Then smearing of the material will take place. The press will get jammed, unless the production flow will be decreased fast enough, and/or the quality of the

material can be adapted, and/or other emergency measures can be taken for preventing jamming.

It is an object of the invention to provide a press of the kind mentioned above not having these objections or only to a considerable lesser degree, and allowing an optimal adaptation to the material to be processed. To that end the press according to the invention has the characteristics mentioned in the characterizing portion of claim 1.

Particular characteristics favourable for the practical application of this press are mentioned in the sub-claims.

In contrast to the known presses, as well the die as roll (and in the case of a rotatable yoke also the yoke) will be driven according to the invention, so that at the gap the velocity of at least the die or the or each roll is independently adjustable. Thereby the material compressed in the gap between the die and a roll will not be subjected at one side (i.e. at the side of the roll or the die), but at both sides (i.e. at the roll and the die) to shear stresses. At a substantially constant pressure distribution this will mean that the shear stress will be substantially lower than in the case of driving only the roll or only the die, so that the slip boundary will be reached less early accordingly, and the operation can be controlled better. Thereby a larger adjustability of the gap height can be obtained, which will contribute to obtaining an optimal adaptation to fluctuations in the material to be processed, so that, on the one hand, smearing will occur less frequently, and, on the other hand, the choice of the composition will be subjected to less limitations. The lower slip sensibility also means that a shorter running-in period during adjustment of the press can be obtained. The better adjustability of the gap height also means that the production capacity, as far as not restricted by the required minimum hardness and wear resistance and/or other desired qualities of the pressed material, can be considerably increased, so that a possibly favourable result can be obtained.

The invention will be elucidated below by reference to a drawing, showing in:

Fig. 1 a diagrammatic representation of the general

structure of a pelleting press of known design for elucidating the invention;

Fig. 2 a diagrammatic representation of the gap between the die and roll in a press according to the invention, with the velocities and shear stresses occurring therein; and

Figs. 3 and 4 diagrammatic representations of the drive of such a press.

In Fig. 1 a known pelleting press has been diagrammatically shown. This press comprises a hollow cylindrical drum or die 1, provided with a large number of apertures 2 which are generally directed tranversely to the die surface. This die is rotatably supported on an axis 3, and can be rotated by means of driving means, diagrammatically indicated by an arrow 4, with a desired angular velocity, leading to a velocity v_m. This velocity relates to the inner side of the die in the point of smallest gap height. Inside this die, a roll 6 rotatably supported on an axis 5 which is parallel to the axis 3 and laterally displaced in respect thereof, the generatrices of said roll being parallel to those of the die 1. Between the die and the roll a relatively narrow gap 7 is present. The smallest distance between the die and the roll is the minimum gap height 9 (Fig. 2). The gap height can be adjustable.

Inside the die 1,.the material 8 to be pressed is continuously supplied, and is, when rotating the die 1, entrained as a consequence of the friction between the die 1 and this material, the latter being compacted in the gap 7. The pressure then occuring will cause this material to be pressed outwards through the apertures 2 in the form of compressed pieces, generally called pellets. As a consequence of the movement of the material in the gap, the non-driven roll will rotate with a velocity v_r. This velocity relates to the circumference of the roll in the point of lowest gap height.

It will be clear that also various rolls can be arranged inside the die 1, and, instead of driving the die 1, also the roll 6 can be driven, and then the non-driven die will be entrained. In an other known construction, the die does not move, and a yoke is rotatably driven. The rolls are then supported in said rotating yoke. Also the die 1 and/or the

rolls 6 can have a conical shape. It is also possible to provide the apertures 2 in the rolls 6, but this is generally not practical.

Therefore, a velocity gradient will occur transversely to the roll axis 5. If, however, too much slip will occur between the material 8 and the surface of the die 1 and/or the roll 6, this will lead to a certain smearing of the material in the gap, and to a reduction of the pressure, the consequence thereof being a reduced extrusion of the material through the apertures 2. A small internal slip in the material can, indeed, influence the quality of the material in a favourable way since, thereby, a better coherence between the particles of the material and a greater hardness and wear resistance and/or other qualities of the pressed material pieces can be obtained, but the operation will become instable in an increasing degree and, therefore, less controllable, so that the risk that the press will jam will strongly increase.

In these known presses the adaptation to different factors is difficult, and often not optimally possible. If the quality of the material to be pressed will change or fluctuate during a current pressing operation, because of changes of the internal friction as a consequence of, for instance, variations in the humidity or fat content, it is generally not possible to perform a supplementary adjustment during the operation leading to an optimal pressing result. Also the character of the material to be pressed will not allow an optimal or economically feasible pressing operation within the adaptation and adjustment possibilities of the press.

The invention is based on the insight that the difficulties mentioned above can be avoided by a better adjustability and control, or can be considerably reduced. To that end also the roll 6 will be driven, as shown in Fig. 1 by an arrow 4', so that also the roll will exert a driving friction force on the material 8 in the gap 7. The entraining force required for generating the required pressure in the gap 7 will then act at both sides on the material, so that the critical friction force at which slip is beginning to occur will occur less early, and virtually never at a suitable choice of the velocities and the gap height.

Fig. 2 diagrammatically shows this transverse forces. The die 1 having a radius R_m is driven at an angular velocity ω_m, leading to a velocity v_m. The roll 6 having a radius R_r is driven at an angular velocity ω_r, leading to a velocity v_r. The shear stresses τ_m and τ_r exerted on the material by the die and roll are not only dependent on the rotation angle, but are also a function of the velocities which are mutually indepently adjustable.

It has now appeared that the possibility of slip will be at a minimum if the shear stresses τ_m and τ_r at opposite sides of the gap are substantially equal. From mechanical considerations it will appear that, then, in the curved plane 10 substantially in the centre of the gap 7 the shear stress will be zero. This plane is called a neutral plane. The pressure generated in the compressed material will then i.a. depend on the sum of these shear stresses and the gap height. This pressure will then be selected as high as possible, but is limited by the condition that uncontrollable slip should be avoided under all circumstances.

It will now be clear that by selecting suitable driving velocities for the die 1 and the roll 6, and in particular of the ratio of these velocities, and furthermore of a suitable height of the gap 7, an optimal adjustment for a given material can be obtained which, in particular during the operation of the press, can be adapted. In particular the running-in period of the press can be considerably accelerated thereby, so that less time and material will be lost. By adjusting a small velocity difference between the die and the roll, a given controllable slip and internal shear in the material can be generated, so that the quality of the material in the gap can be favourably influenced while avoiding the risk of the press becoming jammed.

The last-mentioned equality of the shear stresses τ_m and τ_r can be obtained in the case of fixedly mounted rolls 6 and die 1 as such by an adapted adjustment of the rotational velocities. In the general case of a yoke rotatable round an axis 3 and rolls 6 supported in this yoke on the other hand, the drive of the rolls 6 in respect of the yoke, the drive of the yoke in respect of the stationary structure, and the drive

of the die in respect of the stationary structure, should be selected so that the shear stresses τ_m and τ_r are substantially equal. This can be obtained by a correct adjustment of the velocity of the roll and the die at the gap in question.

A simple construction of a pelleting press according to the invention comprises a driven roll and a driven die, the yoke being fixedly mounted in respect of the casing (Fig. 3). An other possibility is a press having a stationary mounted die, a driven yoke, and a roll driven in respect of this yoke (Fig. 4).

According to the invention the die 1 and the roll 6 (as the case may be also by means of a driven yoke) can each be driven in such a manner that the circumferential speed of the roll and the die in the narrowest part of the gap can be continuously variably adjustable independently from each other.

Then these adjustable drives can be mutually coupled in such a manner that the ratio between both velocities when varying these velocities is constant but is variable in function of the cap heigth. When controlling these adjustments, use can be made of relationships which can be derived from mechanical equilibrium condition, and which can be of an approximating functional and whether or not simplified and possibly experimentally determined kind. Of course use can be made of an adapted microprocessor. The condition for control is that the drive of the press should be so that the shear stresses τ_m and τ_r are substantially equal.

The integral of the shear stresses τ_m or τ_r over the circumference and width (in the gap in question) of the die or the roll is a measure for the respective circumferential force in respect of the die or roll. Since, in a gap, the shear stress at the roll and die should substantially be equal this means that the circumferential force of the roll should be substantially equal to the cirumferential force of the die at a gap. This means that the press according to the invention can be controlled on the basis of the circumferential force or the driving torque. For, by multiplying the radius R_r of the roll or R_m of the die by the respective circumferential force the

driving torque for each cap of the roll and the die respectively is obtained. The press according to the invention can, therefore, be controlled in such a manner that the quotient of the driving torque of the roll and the roll radius R_r will be substantial equal to the driving torque of the die for each gap and the respective radius R_m of the die.

Since the slip between the roll and the die is relatively small, the circumferential velocities of the roll and the die will be substantially equal. As the product of the circumferential speed and the circumferential force is equal to the power, this means that the power mechanically supplied to a roll should be substantially equal to the mechanical power which is supplied to the portion of the die co-operating with this roll. The press according to the invention can, therefore, be controlled also in such a manner that the mechanical power supplied to the roll is substantially equal to the power of the portion of the die co-operating with this roll.

Therefore the press can be controlled i.a. on the basis of velocity, driving torque or power.

Controlling the press on the basis of velocity, driving torque or power can be realized in many ways by means of known techniques. Some examples thereof shall be mentioned now.

If the drive of the roll and the die takes place hydraulically by means of hydromotors, the velocity or number of revolutions of the roll and the die can be adjusted for instance by controlling the volume flow towards the hydro-motors in question. If control takes place on the basis of driving torque or hydraulic power, information in respect of the hydraulic pressure or the hydraulic pressure and the rotational speed respectively will be sufficient.

In the case of a mechanical drive the velocity of the roll and the die can be adjusted by controlling the rotational speed of the roll and the die, for instance by means of a continuously variable mechanical transmission.

In the case of controlling on the basis of the drive torque or power, use can, for instance, be made of strain gauges on the drive shaft for determining the driving torque.

In the case of an electrical drive of the roll and the

die, the velocity can be adjusted by controlling the rotational speed of the roll and the die (e.g. by frequency control). If control takes place on the basis of driving torque or power, a measurement of electrical magnitudes such as voltage (V), current intensity (A) and electrical power (kW) provide sufficient information.

It will be clear that various combinations are possible.

These adjustable drives can be mutually coupled in such a manner that the ratio between both velocities when varying the latter will be constant but variable in function of the cap height. For controlling these adjustments, use can be made of relationships derived from mechanical equilibrium conditions, which are whether or not simplified proximative functional and possibly experimentally determined relationships. Of course use can be made of an adapted microprocessor. The condition for control is that the drive of the press should be so that the shear stresses τ_m and τ_r are substantially equal.

It will be clear that the invention is not restricted to the embodiment shown, and that it can also be used in the case of substantially plane disc-shaped dies.

Claims

1. A pelleting press for pressing from a powdery, granular and/or pasty material compacted rod-shaped pieces of said material, comprising a die with one or more rotatable rolls co-operating therewith each having an axis supported in such a manner that it is situated in a plane through the axis of the die, the generatrice thereof which is nearest to the die being situated at a small distance from and substantial parallel to a corresponding generatrice of the adjacent surface of the die, in order to define a gap between the die and said roll, said die or the or each roll being provided with extrusion apertures, the support of the die and/or the roll or rolls being so that the gap height is adjustable, further comprising means for supplying the material to be pressed towards the or each gap, and driving means for moving the die and the or each roll in respect of the material supplied to the or each gap, all this in such a manner that the supplied material when moving in the gap between the die and a roll is compacted and is pressed through the apertures, **characterized in that** the driving means are adapted for driving the die as well as the or each roll, and that the velocity of at least the die or the or each roll is independently variable.

2. The press of claim 1, **characterized in that** a plurality of rolls is arranged in a yoke, and that the driving means are adapted for driving the rolls in respect of the yoke, and the yoke in respect of the die or vice versa.

3. The press of claim 1 or 2, **characterized in that** the velocity control is adapted for adjusting the ratio between the velocity of the die and that of the or each roll at the smallest gap height and dependent on the adjusted gap height.

4. The press of any one of claims 1..3, **characterized in that** the velocity control is adapted to adjust the ratio between the velocity of the die and that of the or each roll at the smalles gap height in such a manner that the shear stresses exerted by the die and a roll on the material put through will substantially be equal.

5. The press of any one of claims 1..4, **characterized**

in that the driving means are constructed in such a manner that the ratio between the driving torque exerted by a roll on the material put through and the roll radius is substantially equal to the ratio between the torque exerted by the die portion co-operating therewith and the die radius.

6. The press according to any one of claims 1..3, **characterized in that** the driving means are constructed in such a manner that the mechanical power supplied by a roll is substantially equalto the power supplied by the die portion co-operating with said roll.

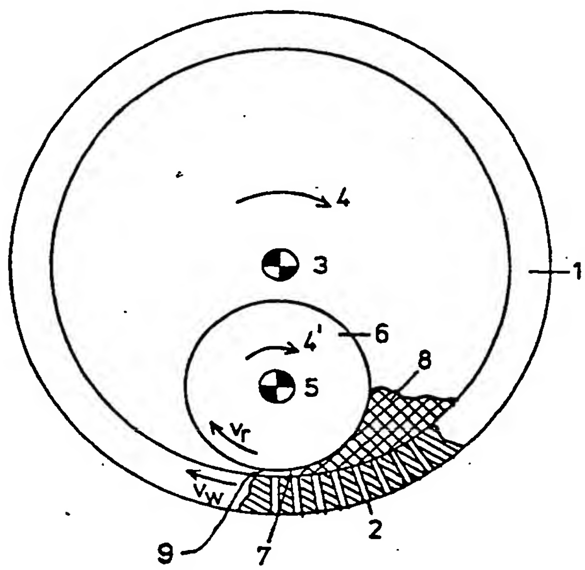

FIG. 1

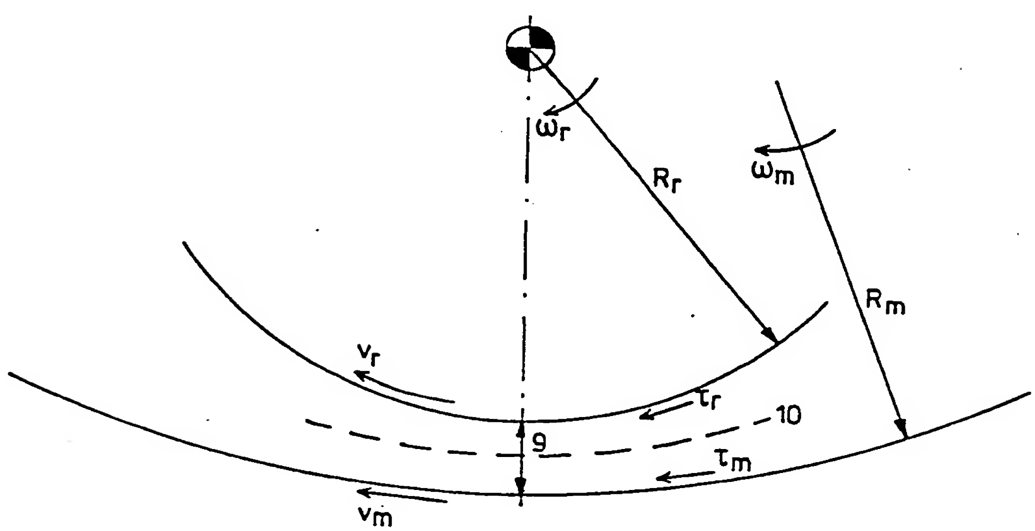

FIG. 2

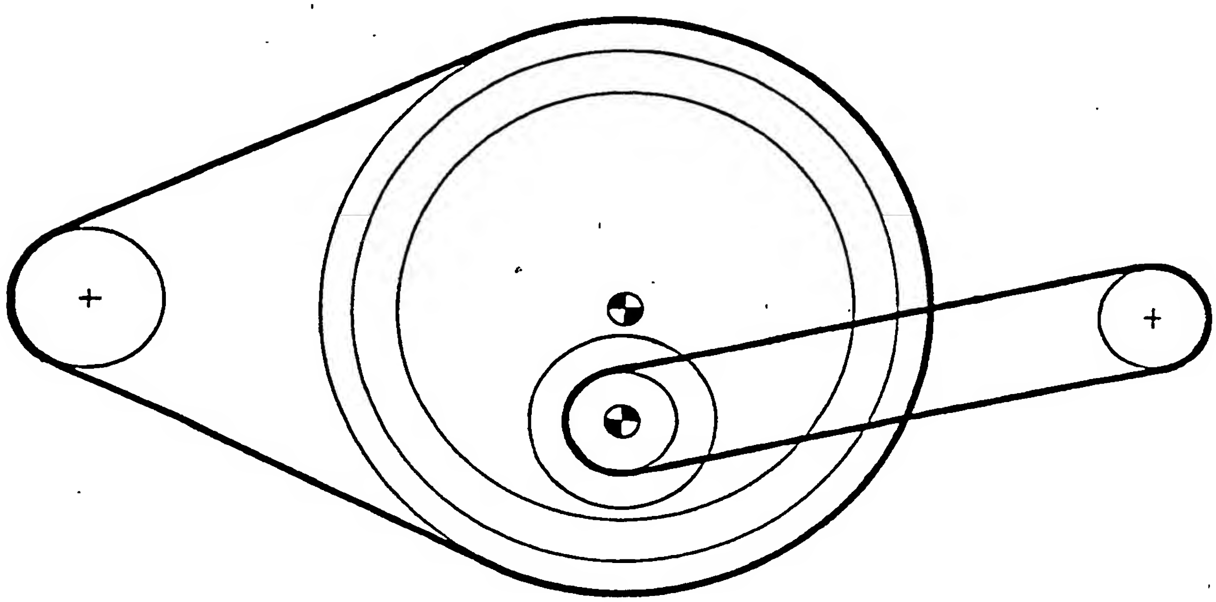

FIG. 3

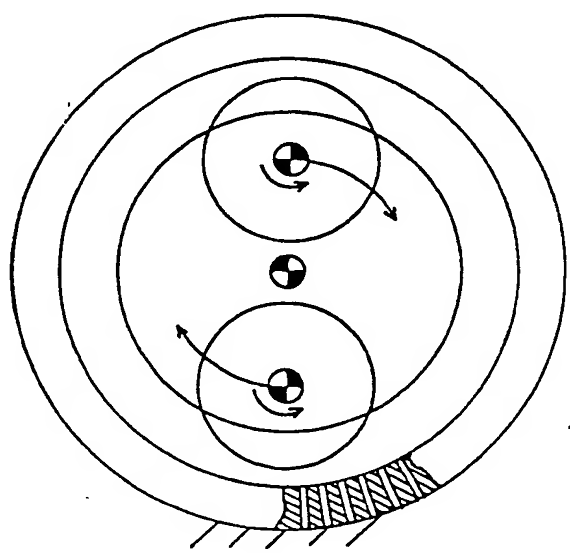

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No PCT/NL 90/00118

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: B 30 B 11/20

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	B 30 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A, 3207091 (CUNNINGHAM) 21 September 1965 see the whole document --	1
P,X	DE, A, 3806945 (AMANDUS KAHL) 14 September 1989 see the whole document --	1,2
Y	GB, A, 2130959 (RU-KORREL) 13 June 1984 see the whole document --	1
Y	FR, A, 1568226 (POLYSIUS) 23 May 1969 see the whole document --	1
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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
9th November 1990	23. 11. 90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	miss T. MORTENSEN

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. NL 9000118

SA 39293

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The members are as contained in the European Patent Office EDP file on 19/11/90
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 3207091		None	
DE-A- 3806945	14-09-89	None	
GB-A- 2130959	13-06-84	AU-A- 2099283 US-A- 4498856	10-05-84 12-02-85
FR-A- 1568226	23-05-69	None	
FR-A- 555203		None	
FR-A- 1274122		None	

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